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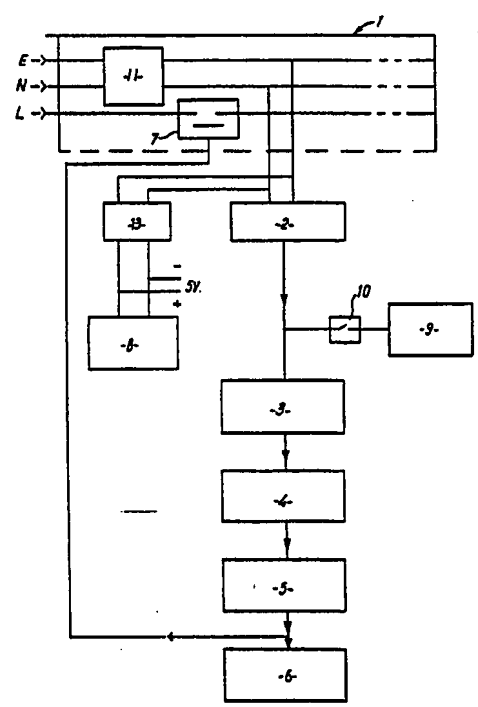
(54) Title: APPARATUS AND METHOD FOR DETECTING A POTENTIALLY FIRE GENERATING ELECTRICAL FAULT

(57) Abstract

An electrical fault detection apparatus comprises a detector (3), a threshold detector (4), duration discriminator (5) and warning device (6). Electrical signals radiated due to a fault having a certain frequency, above a certain amplitude and of a certain duration are detected and employed to activate a warning device (6) to indicate a fault condition in an electrical cable likely to lead to a fire.



APPARATUS AND METHOD FOR DETECTING A POTENTIALLY FIRE GENERATING ELECTRICAL FAULT

The present invention relates to apparatus and method for detecting a potentially fire generating electrical fault.

The fire risk of electrical faults in electrical supply systems particularly, but not exclusively in buildings, is well known.

An object of the present invention is to provide means to detect electrical faults which are likely to cause a fire risk, at an early stage before a fire is likely to occur. The current method of preventing electrical fires is to provide an overload isolation device such as a fuse or an overload circuit breaker. These devices isolate excessive currents flowing from short circuits after a very short time. In this way, the joulean heating in cables is limited and hence the cables do not set on fire. However, a second form of fire hazard has been recently investigated and it is believed that a large number of domestic and indeed industrial fires start in this way. This hazard arises from an intermittent break in a cable, by either damage, excessive flexing in operation or incorrect connection and termination. Neither fuses nor circuit

breakers respond to this type of fault. The present invention relates to apparatus for and a method of dealing with the potential hazard.

If there is a break in continuity in either the live or neutral of a mains supply to a load, then any vibration will cause the circuit to momentarily switch on and off at the break with a resulting arc. The arc can be especially severe in the presence of a non-deionised water, and it has been demonstrated that such an arc can in a worst case create a fire within about 8 seconds given the appropriate circumstances where there is a fracture in either the live or neutral wire of a flexible cable supplying an object such as a washing machine. Under these circumstances, the electrical load of the appliance limits the current flow, neither fuses nor earth leakage circuit breakers offer any protection. Indeed, the machine continues to function albeit spasmodically whilst a fire is started.

Experiments have shown that arcs arising from breaks and bad connection generate significant energy in the radio frequency spectrum. In the frequency range of a few hundred KHz, the energy is particularly strong and indeed propogates with minimal attention over the whole mains cable network certainly to cover wiring within a domestic house or small industrial premises. Following the first such arcing, there is often damage to nearby

insulation resulting in the formation of carbon tracks. Further the copper conductors work harden and further flexing exacerbates the break. If the break is in the open state, the appliance will of course not function. Nonetheless, small currents of a few milliamps flow along the carbon tracks and such currents also generate r.f. signals but at a significantly low level than that generated by the arc itself.

Commutator motors generate arcs in normal use and the r.f. generated by such machines are of the same size as that generated from a dry break in a mains cable. However, for a number of years the BS800 specification has been applied and conforming appliances have to contain suppression filters to limit the energy of r.f. propogated especially in the region of 160KHz. Measurements have shown that arcs in faulty cables generate a signal similar to unsuppressed commutator motors such as hand drills. However, BS800 suppressed hand drills generate r.f. at least an order of magnitude less. Suppressed thyristor devices, such as dimmer switches, produce even lower levels of r.f. It is concluded, therefore, that in a normal environment, arcs generated from faulty cabling can be detected by using devices to measure the r.f. energy present on the mains network within the premises. The level of this energy is sufficiently different to enable discrimination to be achieved over the above normal domestic and light

industrial and commercial appliances operating within the BS800 specification.

According to one aspect of the present invention there is provided apparatus for detecting an electrical fault in an electrical supply system, characterised by means for detecting an electrical signal radiated within a given band of the radio frequency spectrum, means for determining if the amplitude of that signal exceeds a certain threshold, means for determining if the duration of the signal exceeds a certain value and means for indicating when such a signal above the threshold amplitude and above the duration value has been detected whereby to indicate fault conditions.

According to another aspect of the present invention, there is provided a method of detecting an electrical fault in an electrical supply system, characterised by the steps of detecting an electrical signal radiating within a given band of the radio frequency spectrum determining if the amplitude of that signal exceeds a certain threshold, determining if the duration of that signal exceeds a certain value, and indicating if such a signal above the threshold and above the duration value has been detected whereby to indicate fault conditions.

In order that the invention may be more clearly understood embodiments of the invention will now be described, by way of example with reference to the accompanying drawings, in which:-

Figure 1 shows a block circuit diagram of a first form of detection apparatus according to the invention,

Figure 2 shows a block circuit diagram of a second form of detection apparatus according to the invention, and

Figure 3 is a detailed circuit diagram of the main parts of the embodiment of Figure 1.

Figure 1 shows part of a mains network 1 to which is attached an interface unit 2, the purpose of which is to provide a low impedance path for the r.f. whilst blocking the very much larger 50/60Hz mains signal.

It is considered that the best frequency of operation is about 170KHz with a bandwidth of about 10KHz to 20KHz. This range will enable the filter to reject 200KHz signals for radio 4 on long wave and will enable significant attenuation of signals at 150KHz which will be increasingly used by security systems

operating with mains borne signalling. Unit 3, provides for an r.f. detector, which will operate at the chosen centre frequency and will provide the desired bandwidth.

The level of r.f.signal detected is then processed by a threshold detector 4, which provides a warning signal if the r.f. exceeds a predetermined threshold. Signals generated from normal devices will also generate r.f. but these will not exceed the predetermined threshold. Arcing typically generates mains borne noise in the frequency band 160KHz to 180KHz in pulses of minimum duration of 500ms of amplitudes from 10mV to several volts. Background noise in the same frequency band in a typical mains installation under normal operating conditions contains pulses of up to 200ms duration of amplitudes up to 40mV. Shorter pulses in the order of microseconds can have amplitudes up to several kilovolts. BS800, to which all domestic appliances must conform, allows r.f. pulses of 200ms duration or longer up to 6mV amplitude. A minimum amplitude threshold level of 6mV is therefore proposed.

Arcing occurs when any switch closes or especially opens an active electric circuit. For example when turning off a light a pulse of r.f. of considerable magnitude is generated. However, arcs from faulty connections occurs over a much greater time duration. The warning signal is passed to the duration

descriminator, 5, the purpose of which is to produce a signal only if the large r.f. signal is present for longer than a predetermined time as indicated above. The r.f. signal may be generated in a stream of closely spaced signals. The duration descriminator typically may be set to deliver a fire risk signal if the r.f. persists for 0.6 or more seconds. The descriminator will contain a predetermined time constant, typically less than one second, such that a pulsed stream of r.f. signals more closely spaced than this predtermined time constant, will be treated as a continuous signal. The object of this discriminator 5, is to prevent alarm signals being generated by bouncing switches in normal appliances.

The descriminator generates a latched alarm signal which then can be used to drive some warning device which may be audible and/or visible. The option also exists to use this signal to operate a latched circuit breaker 7, which isolates the circuit.

A typical device may generate the d.c. power source to operate its circuits from either an internal battery or more likely from a power supply unit, 13, deriving a low voltage d.c. supply from the mains. In certain situations it may be desirable that an embodiment of the device may be connected to the mains via a switched socket. It is undesirable that such a

device be inadvertently disconnected by switching the socket off. The device should therefore be fitted with power-off warning means, 8. The simplest way to generate such a warning is to provide a warning light to indicate active connection to the mains.

As the proposed device is typically passive in a normal environment and may remain so for very considerable periods of time, it is important to supply means to test the system. It is proposed that a test signal generator, 9, be incorporated to provide an r.f. signal of the correct amplitude. This is connected to the device by switch 10, which typically would be a test button. On pressing, 10 for a period longer than the predetermined duration in the descriminator 5, then the correct action of the device would ensue. The r.f. signal generated would also pass through the mains interface and would be transmitted via the network to any other like devices which were connected. They in turn would be activated by the test signal and this would test the integrity of the entire connection through the network. This is important because certain loads such as TVs, fluorescent fittings and washing machines etc contain capacitors across the mains, with the result that r.f. signals are strongly attenuated at such a load. This problem can be overcome by using a number of devices strategically placed. Some devices could be built into accessories. For example, a double

sized socket could contain one single mains outlet together with an associated safety device occupying the adjacent space. To solve the attenuation by fluorescent systems, light fittings could be designed with a safety device incorporated.

As an alternative solution, it is technically possible to modify the capacitative filter in some of these appliances in order that r.f. propagated on the mains network is not significantly attenuated. The application of mains-borne signalling requires this to be done. In certain cases, mains adaptors containing the necesary filter elements must be inserted between the device and the mains socket. Such devices would also permit propagation of r.f. signals due to faulty wiring to be detected by the described invention.

In certain applications, where the devie is required to isolate a zone of the mains network if a fault is detected in the zone, such as 1, in figure 1, by activating the circuit breaker 7. It may be appropriate to include a low pass filter, 11, so as to prevent r.f. generated by faults or during test from affecting the remaining network. Similarly, any r.f. activity on the remaining network will be isolated by the filter 11 and prevent it from triggering a response in the protected network, 1. This is especially important if the device is resident in a consumer unit.

If two adjacent properties operated such a system without the filter, 11, present, then faults in one, would result in disconnection of both; clearly undesirable. In the same way it will be desirable to fit a low pass filter, 11, in a consumer unit to avoid a fault in an adjacent premises supplied on the same phase of the mains, triggering the warning device. Figure 3 shows a detailed circuit implementation of the embodiment shown in Figure 1. In this implementation, for commercial and practical reasons, the circuit breaker 7 and low pass filter 11 have been omitted. The remaining circuit blocks of Figure 1 are enclosed by a dashed line in Figure 3 and identified by the same reference numerals.

By way of example a second embodiment of the device will be described by reference to Figure 2.

Any r.f. signal generated by an arc in a mains circuit not only propagates along the mains network but is radiated as an electromagnetic wave. As the mains network is large and acts as an arial, the radiation is of a significant magnitude such as to make detection within the premises relatively easy.

This can be done in a free standing device acting as an r.f. detector being provided with an aerial, 14, connected to an r.f. detector and filter,

15. Again it is suggested that 170kHz with a 10 to 20 kHz bandwidth be mose appropriate as before described.

The signal generated is then passed to a threshold detector, 16 and a duration descriminator, 17 which feeds some warning device 18. These functional blocks perform the same function as blocks 4,5 and 6 respectively in Figure 1, and could be of an identical design.

The free standing device would normally be battery operated although power for its operation could be derived from the mains. In the case of battery operation the device would normally be permanently on and the battery condition would be detected by circuit, 20 and if low would initiate a warning by means of item 21.

It may be desirable to operate the device such that any signal indicative of a potentially dangerous fault would trigger latch, 22, which ensures that the warning continues to be activated until the latch is reset by button 23.

The advantage of the free standing device is that it is more portable and does not suffer to the same degree as the mains resident device from capacitative attenuation by specific loads. However, it will be more

difficult to define a clear threshold due to the uncertainty of the coupling between the device aerial and the mains network. It will also be difficult to descriminate between faults in closely adjacent premises as insertion of filters in the consumer unit will not necessarily eradicate the problem. This is because the free standing unit wil be subject to direct radiation through party walls arising from radiation present in the adjacent premises.

It will be appreciated that the above embodiments have been described by way of example only and that many variations are possible without departing from the invention.

CLAIMS

1. Apparatus for detecting an electrical fault in an electrical supply system, characterised by means for detecting an electrical signal radiated within a given band of the radio frequency spectrum, means for determining if the amplitude of that signal exceeds a certain threshold, means for determining if the duration of the signal exceeds a certain value and means for indicating when such a signal above the threshold amplitude and above the duration value has been detected whereby to indicate fault conditions.

2. Apparatus as claimed in claim 1, which is connected to the electrical system in which the fault to be detected would arise.

3. Apparatus as claimed in claim 1, in which the means for detecting comprises an aerial for receiving signals to be detected.

4. Apparatus as claimed in claim 2, in which means are provided for isolating the part of the system in which faults are to be detected from other parts of the system.

5. Apparatus as claimed in claim 2, in which means are

provided to prevent significant attenuation of a signal to be detected by elements in or attached to the system having an inherent capacitive characteristic.

6. Apparatus as claimed in any preceding claim, in which means are provided for indicating that the apparatus is operational.

7. Apparatus as claimed in any preceding claim, in which a signal generator is provided operative to supply a signal to the means for detecting to enable the correct functioning of the apparatus to be checked.

8. Apparatus as claimed in any preceding claim in which the means for detecting is set to detect a signal having a frequency of about 170KHz with a bandwidth of about 10 to 20 KHz.

9. Apparatus as claimed in any preceding claim, in which the threshold duration value of the signal is more than half a second and preferably one second.

10. Apparatus as claimed in any preceding claim, in which the amplitude threshold is at least 6 millivolts.

11. A method of detecting an electrical fault in an electrical supply system, characterised by the steps of

detecting an electrical signal radiating within a given band of the radio frequency spectrum determining if the amplitude of that signal exceeds a certain threshold, determining if the duration of that signal exceeds a certain value, and indicating if such a signal above the threshold and above the duration value has been detected whereby to indicate fault conditions.

12. Apparatus for detecting an electrical fault in an electrical supply system substantially as hereinbefore described with reference to Figures 1 and 3 or to Figure 2 of the accompanying drawings.

13. A method of detecting an electrical fault in an electricall supply system substantially as hereinbefore described with reference to Figures 1 and 3 or to Figure 2 of the accompanying drawings.

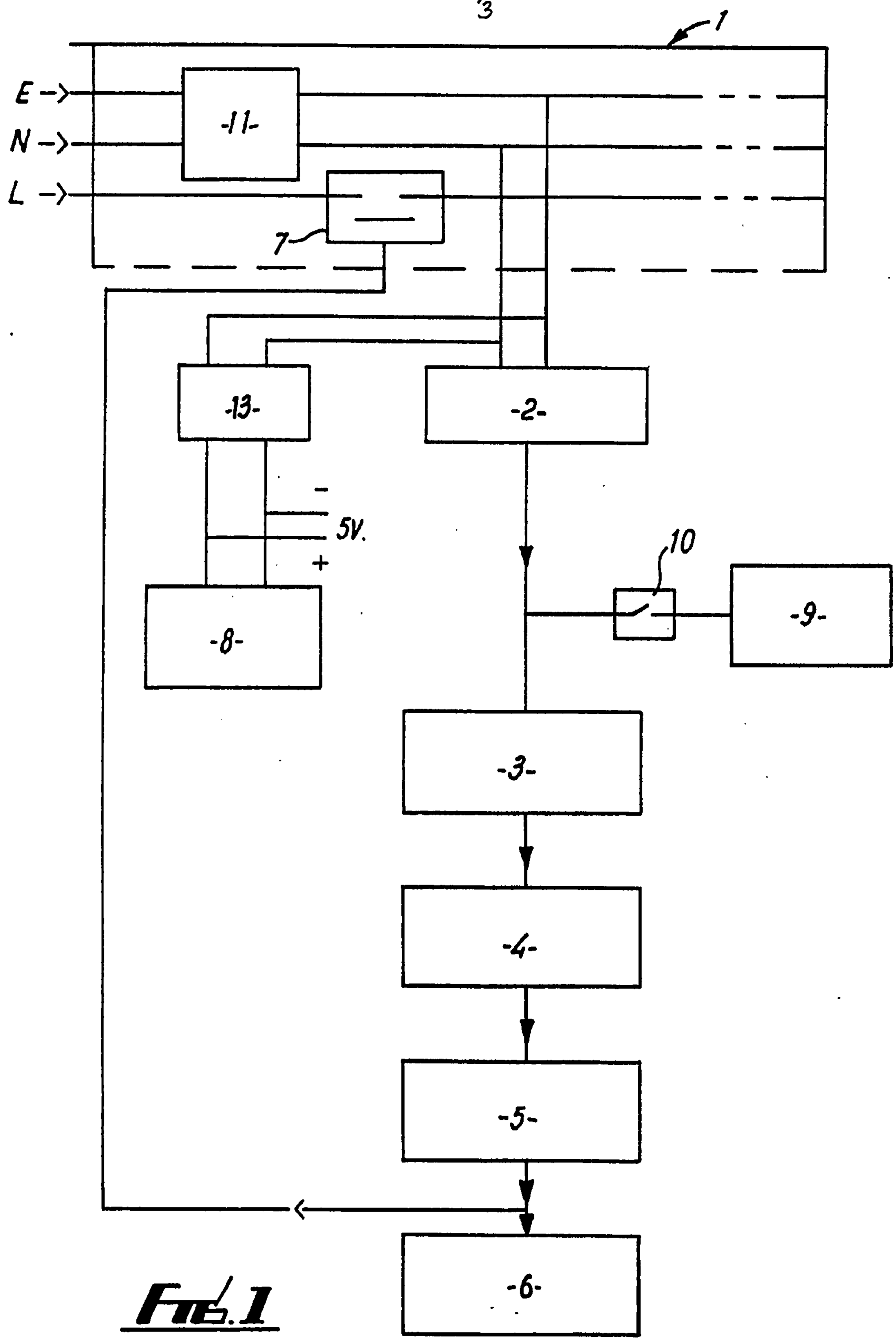


FIG.1

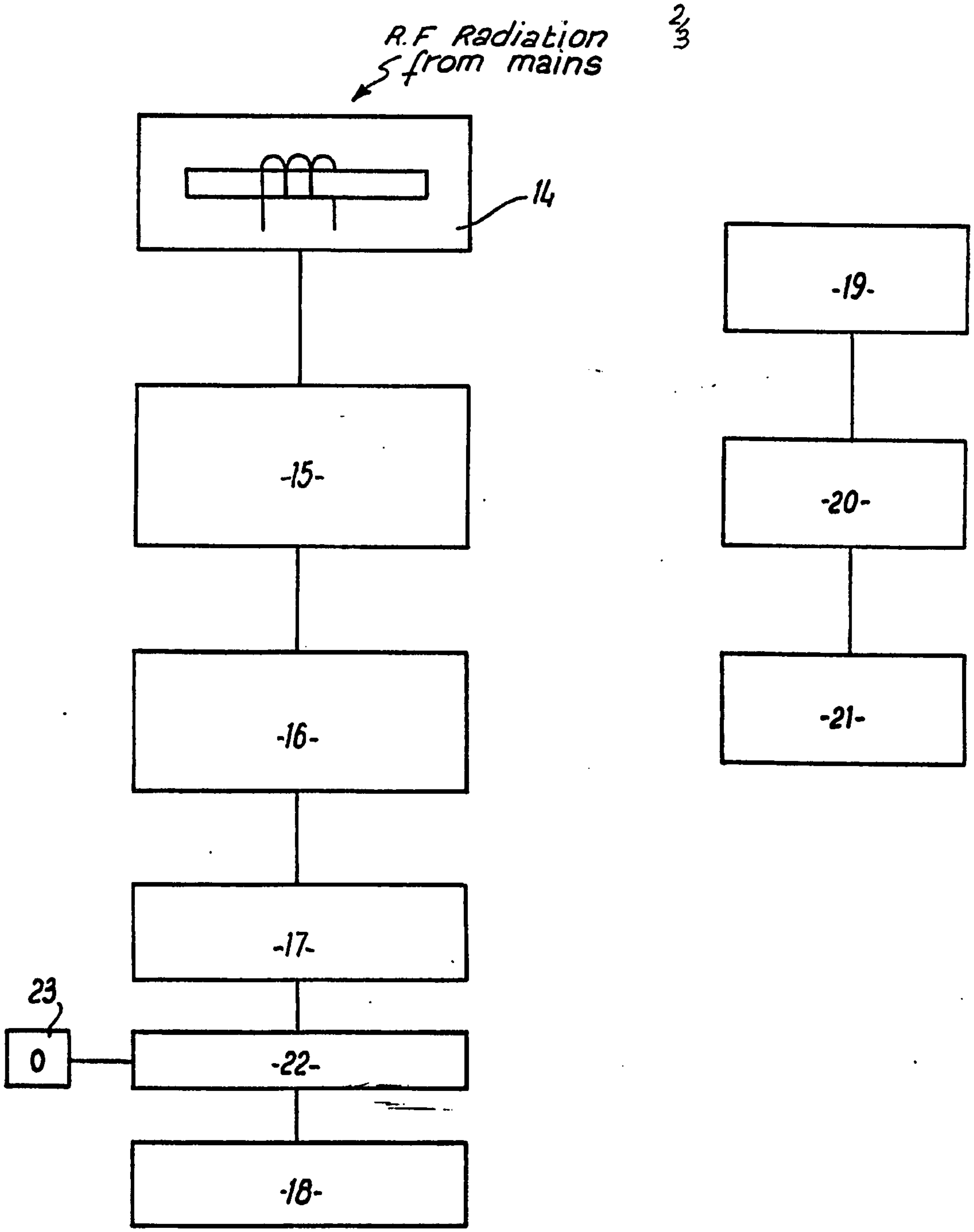


FIG. 2

3/3

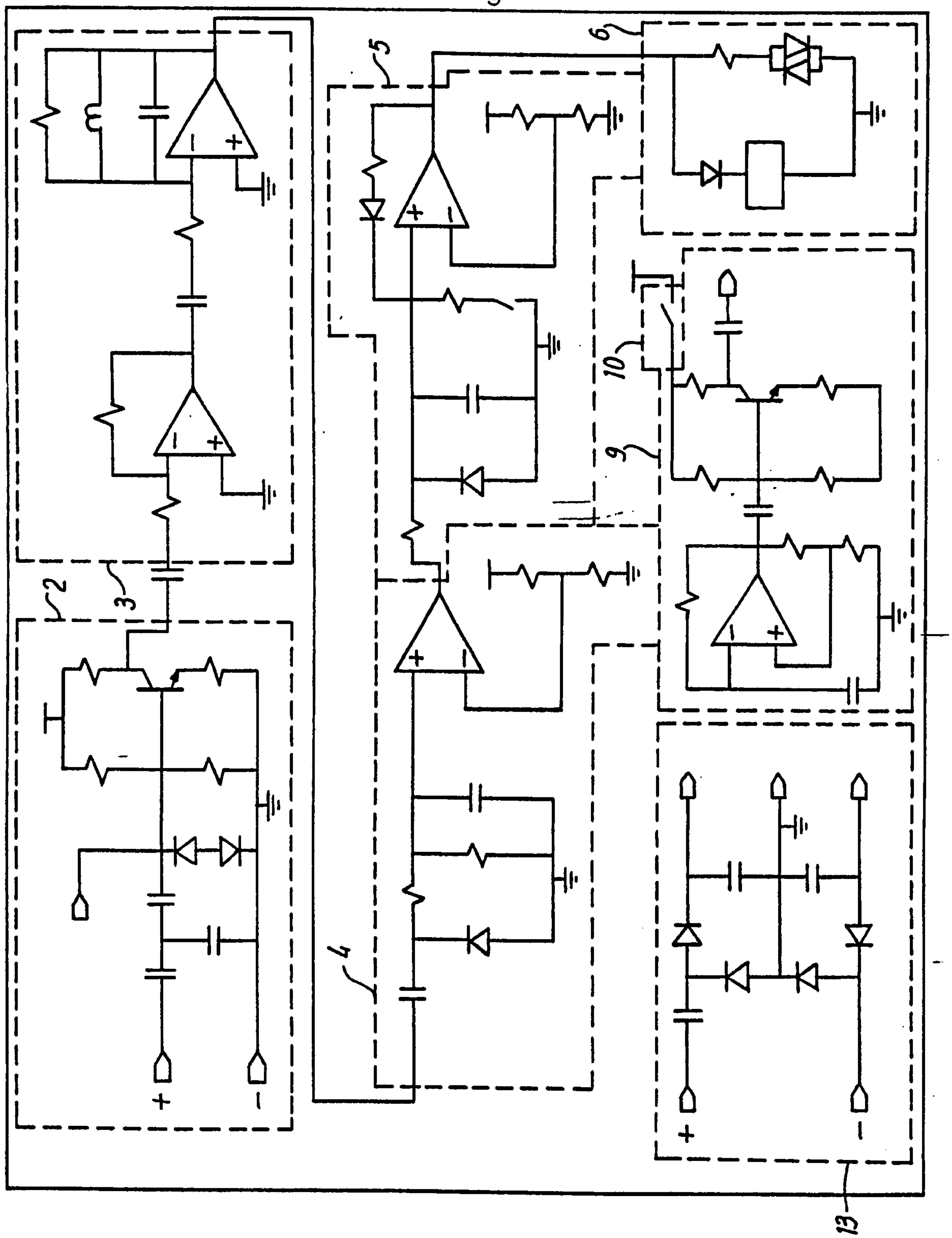


Fig. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/01217

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H02H1/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H02H

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	CH,A,105100 (MASCHINENFABRIK OERLIKON & RUTGERS) 02 June 1924 see the whole document	1-5, 11
X	DE,B,1020410 (MESSWANDLER-BAU GMBH) 05 December 1957 see the whole document	1-3, 11
X	GB,A,1119941 (BOWMAN) 17 July 1968 see the whole document	1-3, 11
A		8
X	US,A,4446426 (EMERY ET AL.) 01 May 1984 see the whole document	1, 2, 7, 10
A		6, 8, 9
X	US,A,4466071 (RUSSELL) 14 August 1984 see column 2, line 25 - column 3, line 51	1, 2, 11
A		3

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 JANUARY 1990	15.02.90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	L. ROSSI

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	FR,A,1536718 (THE ENGLISH ELECTRIC CO. LTD) 16 August 1968 see the whole document ---	1, 3, 11
X	GB,A,1030243 (NAPIER & SON LTD) 18 May 1966 see the whole document ---	1, 2, 5, 9, 11

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

PCT/GB 89/01217
SA 31780

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CH-A-105100		None	
DE-B-1020410		None	
GB-A-1119941		None	
US-A-4446426	01-05-84	None	
US-A-4466071	14-08-84	None	
FR-A-1536718		None	
GB-A-1030243		None	

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